Herp Development

Growth and Development

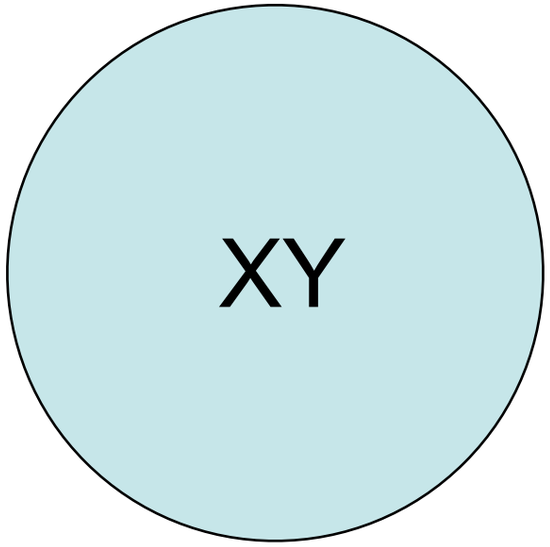
- Sex determination
- Development: embryogenesis and morphogenesis
- Metamorphosis

Growth and Development

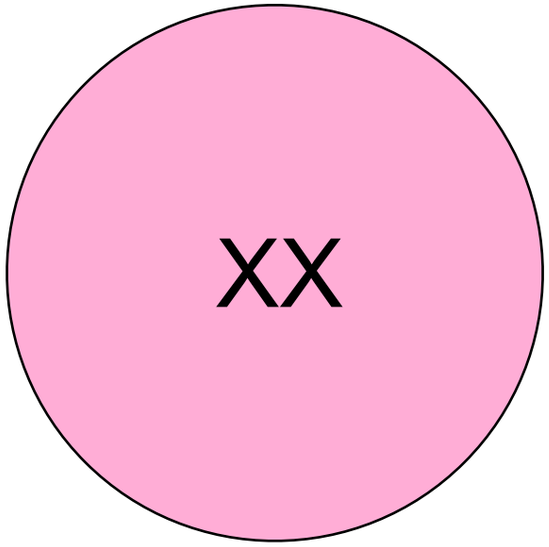
- Sex determination
- Development: embryogenesis and morphogenesis
- Metamorphosis

Sex Determination

- Main types:
  - XY (male heterogametic)
  - ZW (female heterogametic)
  - Environmental sex determination



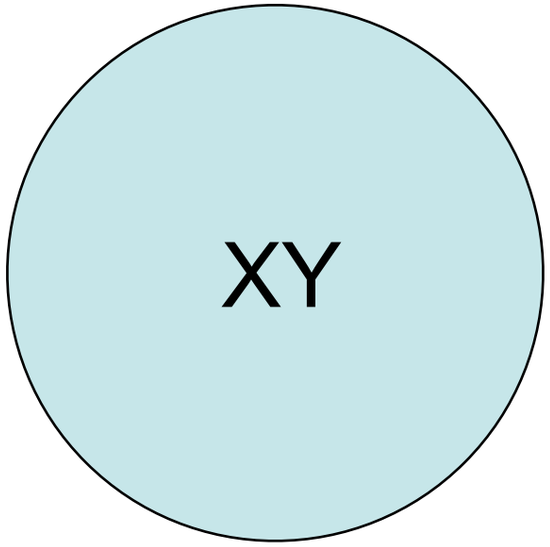
Male



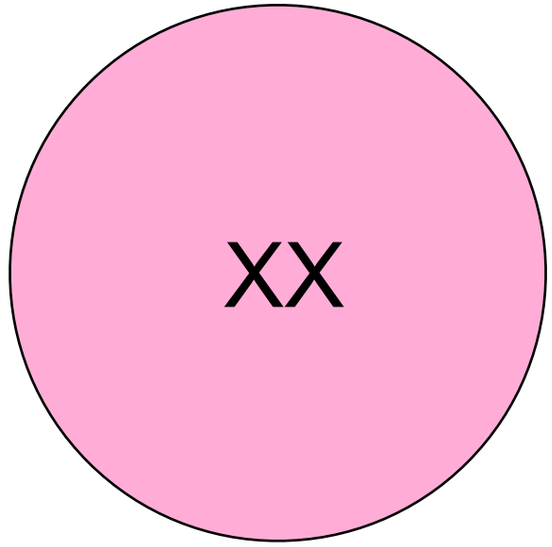
Female

Bombina variegata

Necturus maculosus
Mudpuppy



Male



Female

Matamata turtle (*Chelus fimbriatus*)

Dracaena guianensis

ZZ

Male

ZW

Female

Ambystoma tigrinum
Tiger salamander

Komodo dragon, *Varanus komodoensis*

ZZ

ZW

ZZ

ZZW

ZZ

ZWW

XY

XX

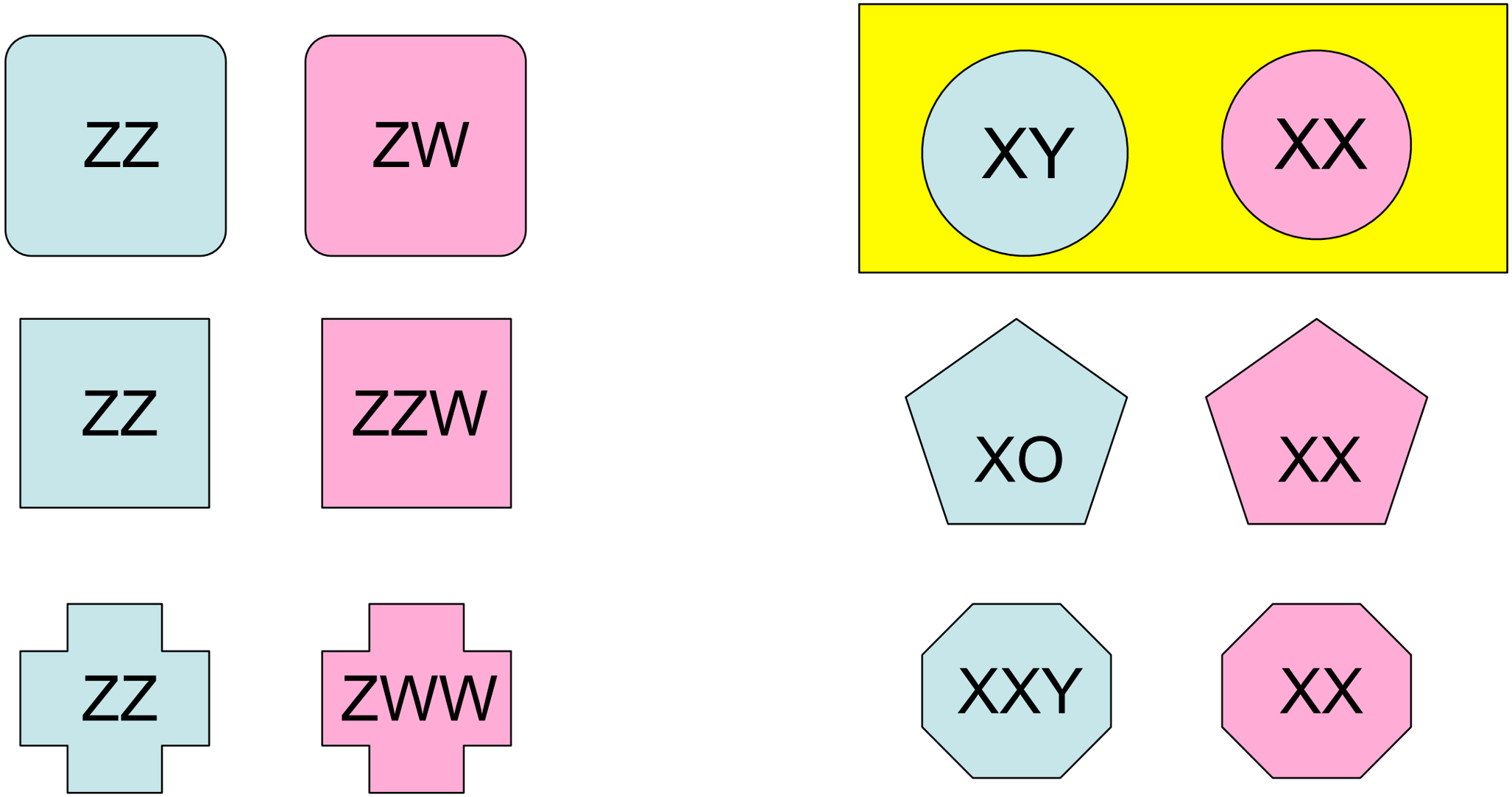
XO

XX

XXY

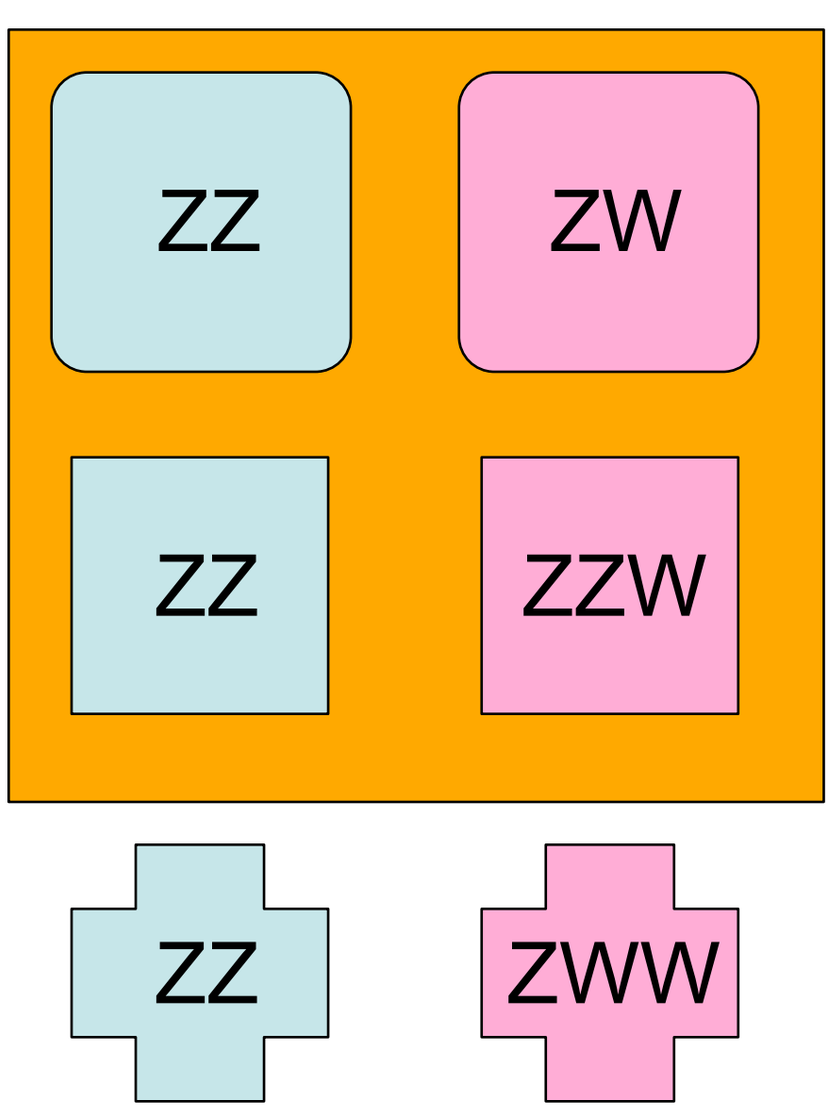
XX

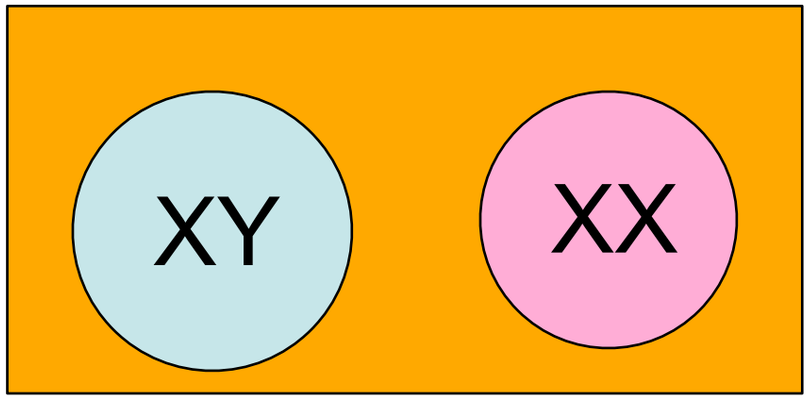
Some groups fixed…

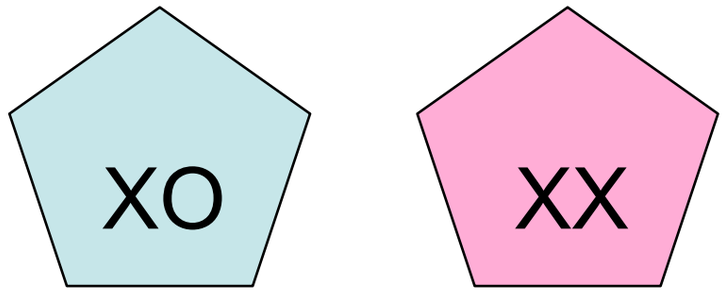


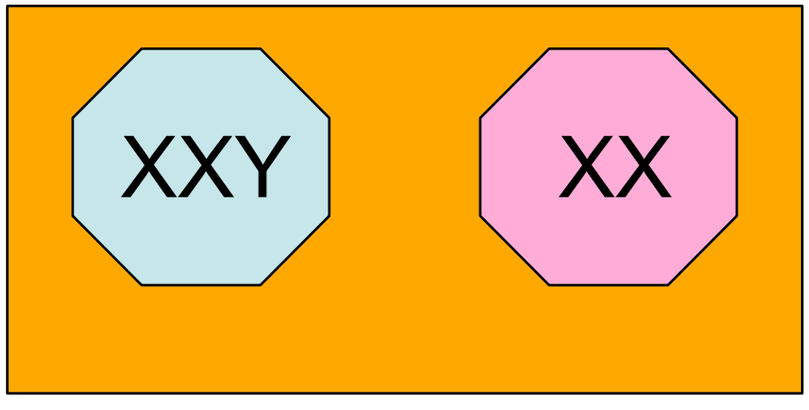
Hylidae

Others variable







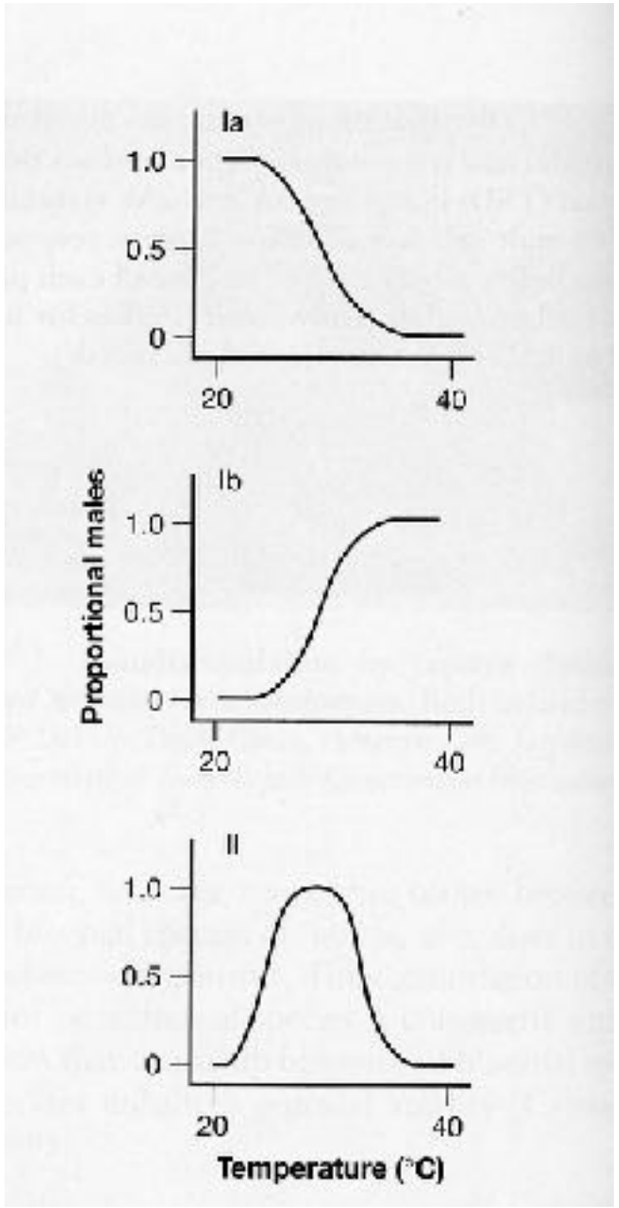


Gekkonidae

Environmental Sex Determination

- Sex of embryo depends on environmental conditions during a key period of development
- Some species of reptiles have temperature-dependent sex determination (TSD)
- Sex depends on temperature of egg incubation during a key window in development

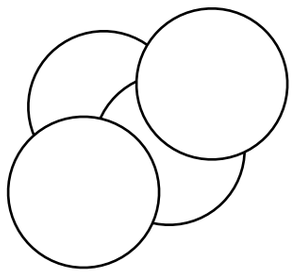
Three main types of TSD

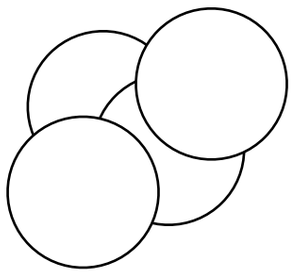


- Type IA (most turtles)
- Type IB (some lizards)
- Type II (some turtles, all crocodylians, some lizards)

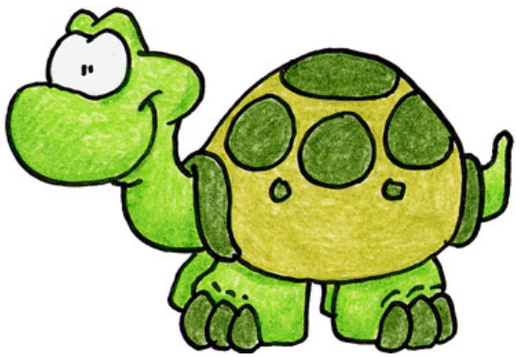
Why TSD?

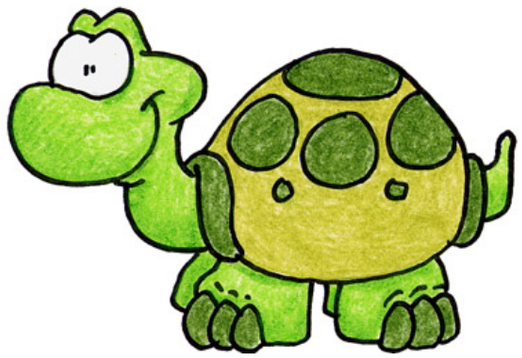
Why TSD?





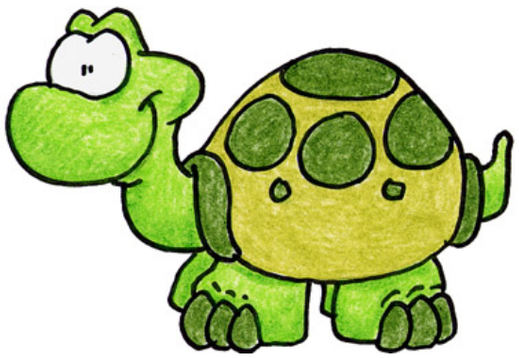
Why TSD?



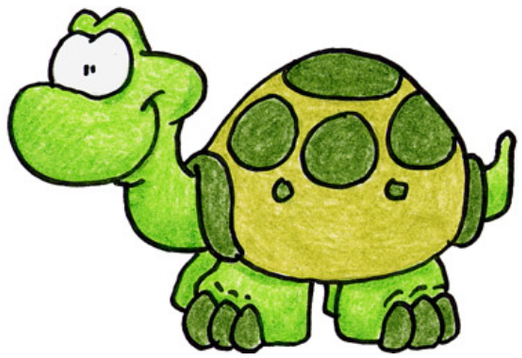


Why TSD?

Female

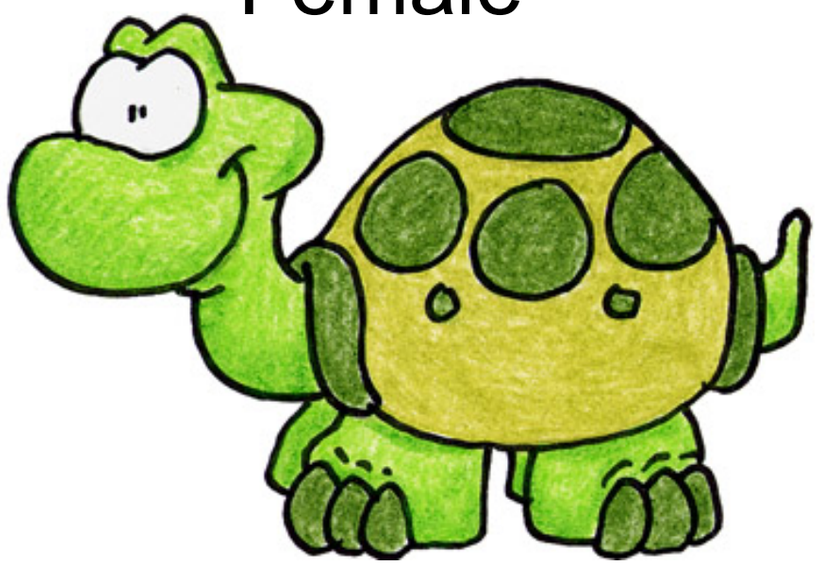


Male

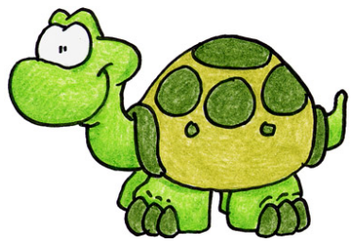


Why TSD?

Female



Male



Adaptive Explanation for TSD

- Fitness of each sex responds differently to incubation temperature
- For example, if bigger is better, but only for females
- Can females choose sex through nest site selection?

Asexual Reproduction

- Most species of reptile and amphibian undergo "normal" sexual reproduction
- At least 50 species undergo unisexual reproduction
- Includes salamanders, frogs, and squamates

Parthenogenesis

Parthenogenesis

- Parthenogenesis occurs when females reproduce without the involvement of males or sperm
- Inheritance is clonal
- All individuals are females

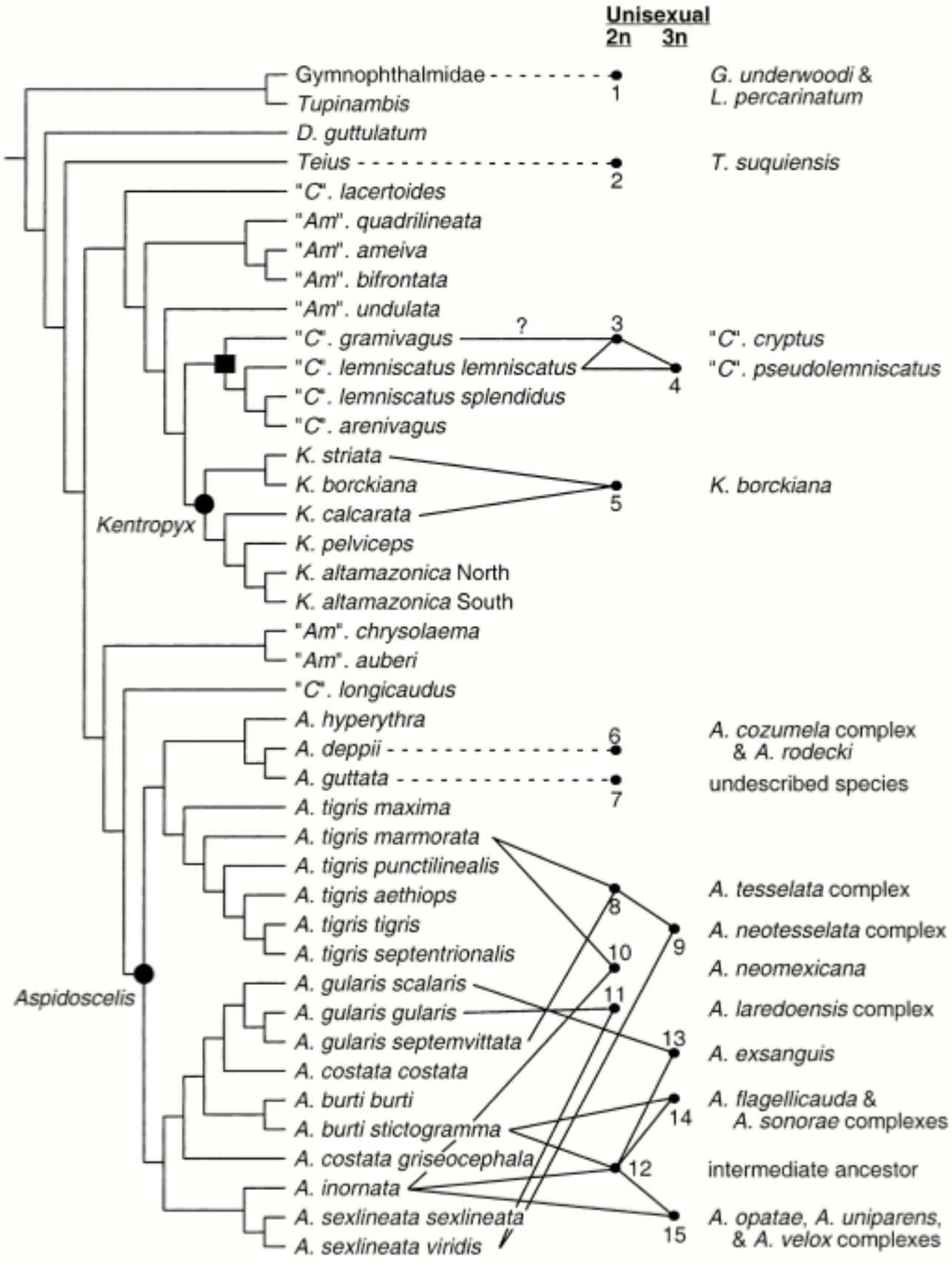
Parthenogenesis

Parthenogenesis

- All known parthenogens are hybrids between two sexual species or the result of hybridization following by backcrossing

Hybrid origins of parthenogenic teiid and gymnophthalmid lizards

from Reeder et al. 2002



Dragon virgin births startle zoo keepers

Non-sexual reproduction could lower the fitness of captive animals.

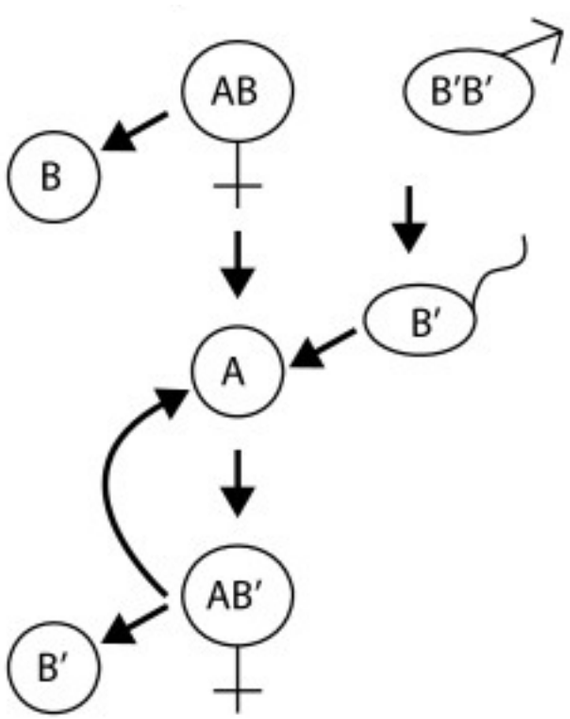
Kerri Smith

A nativity story with a twist is playing out this Christmas in two zoos in the UK. At Chester Zoo, a Komodo dragon named Flora awaits the birth of eight babies, and another four dragons have already hatched at London Zoo — each and every one the product of a virgin conception.

The miraculous births, which are all males, could be a product of keeping this threatened species in captivity, say researchers, and could have implications for the continued health of zoo-bound populations.

Virgin birth: this baby boy has no father. *I. Stephen*

Hybridogenesis



Hybridogenesis

- In species with hybridogenesis, half of the parental genome is passed on while the other half is not
- Known from the *Rana esculenta* complex

Parents Gametes

Parents

R. ridibunda (R)

Gametes

R

R

Parents

R. ridibunda (R)

x

R. lessonae (L)

Gametes

R

R

L

L

Parents

R. ridibunda (R)

x

R. lessonae (L)

Gametes

R

R

L

L

R. esculenta
(LR or LLR)

when e*sculenta* and *lessonae* occur together....

when *esculenta* and *lessonae* occur together....

R. esculenta
(LR or LLR)

L

R

when *esculenta* and *lessonae* occur together....

R. esculenta

(LR or LLR)

x

R. lessonae (L)

L

R

L

L

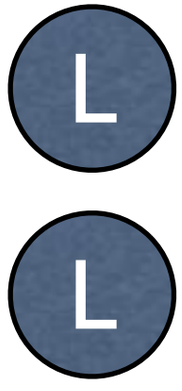
when *esculenta* and *lessonae* occur together....

R. esculenta

(LR or LLR)

x

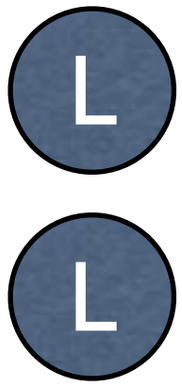
R. lessonae (L)



when *esculenta* and *lessonae* occur together....

R. esculenta
(LR or LLR)
x

R. lessonae (L)



R. esculenta
(LR or LLR)

when *esculenta* and *ridibunda* occur together....

when *esculenta* and *ridibunda* occur together....

R. esculenta
(LR or LLR)

L

R

when *esculenta* and *ridibunda* occur together....

R. esculenta

(LR or LLR)

x

R. ridibunda (R)

L

R

R

R

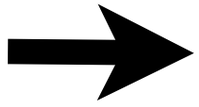
when *esculenta* and *ridibunda* occur together....

R. esculenta

(LR or LLR)

x

R. ridibunda (R)



when *esculenta* and *ridibunda* occur together....

R. esculenta
(LR or LLR)
x

R. ridibunda (R)

L

R

R

R. esculenta
(LR or LLR)

what about interbreeding?

what about interbreeding?

R. esculenta
(LR or LLR)

L

R

what about interbreeding?

L

R

R. esculenta
(LR or LLR)
x

L

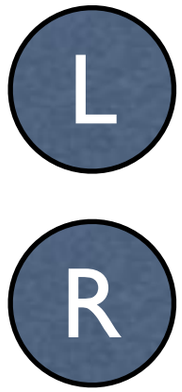
R

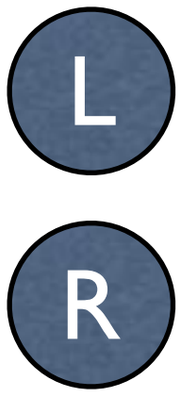
R. esculenta
(LR or LLR)

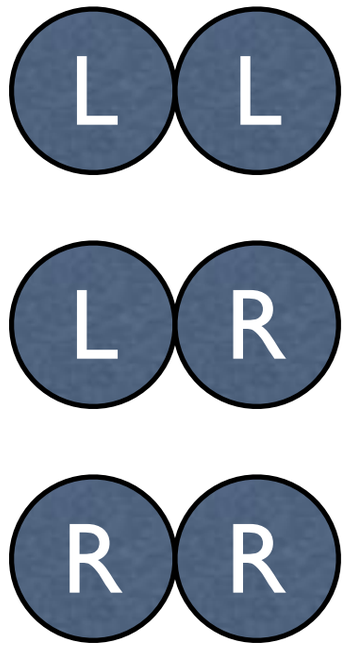
what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)



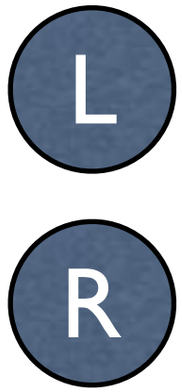


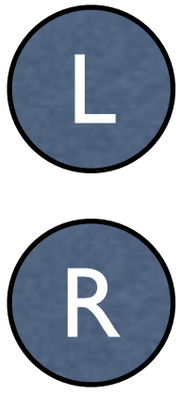


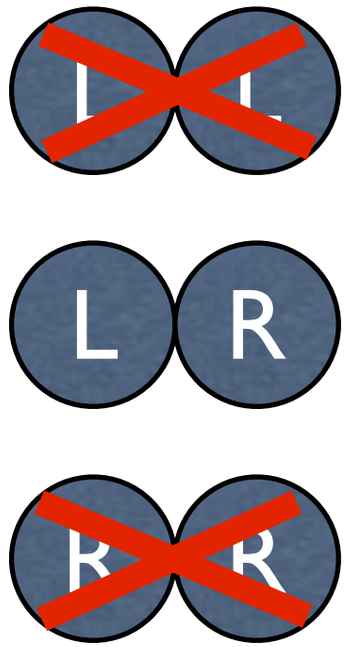
what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)







what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)

L

R

L

R

R. esculenta
(LR or LLR)

Growth and Development

- Sex determination
- Development: embryogenesis and morphogenesis
- Metamorphosis

Embryogenesis

- The formation of the embryo through metamorphosis, hatching, or birth
- Dramatically different between reptiles and amphibians

salamander egg

hatching turtle

Yolk Content

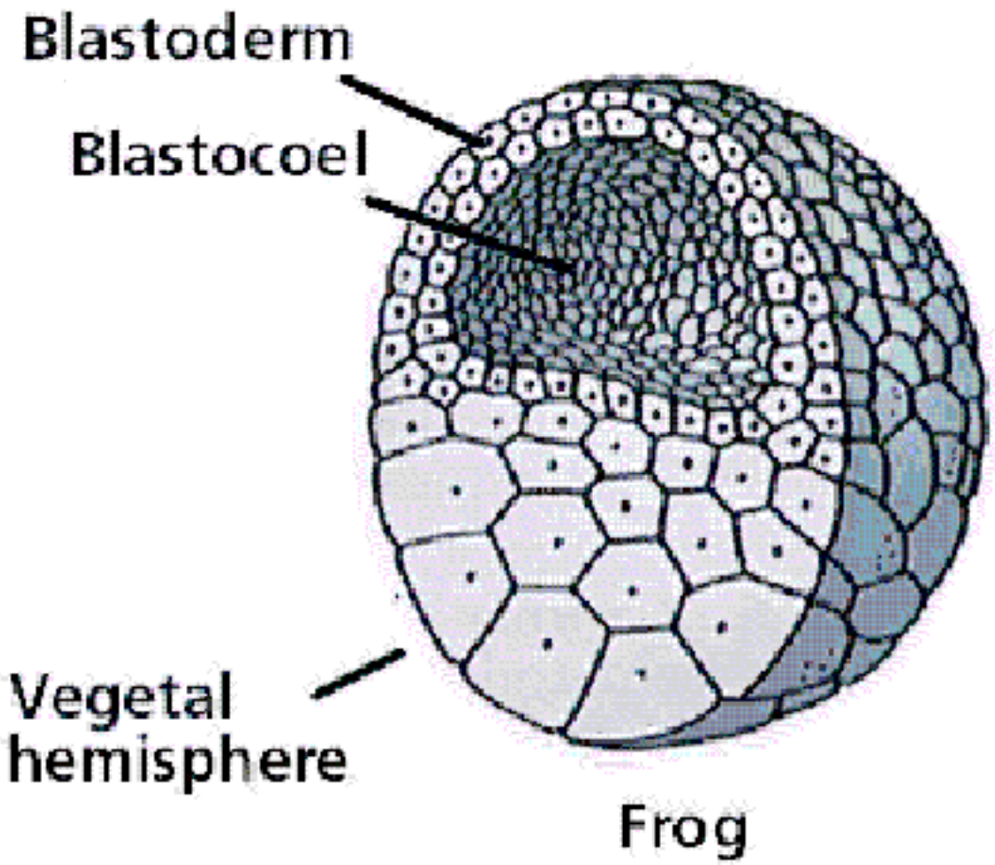
- Amphibians typically hatch at an earlier **larval** stage than reptiles
  - Become free-living at a smaller size
  - Reptile ova typically have **more yolk** than amphibian ova
  - Hatch as fully formed miniature replicas of their parents

Review of Development

- Remember that after fertilization, the zygote undergoes **cleavage** to form the **blastula**
- The blastula sets the stage for all of the growth and patterning of the rest of development

Amphibian Cleavage

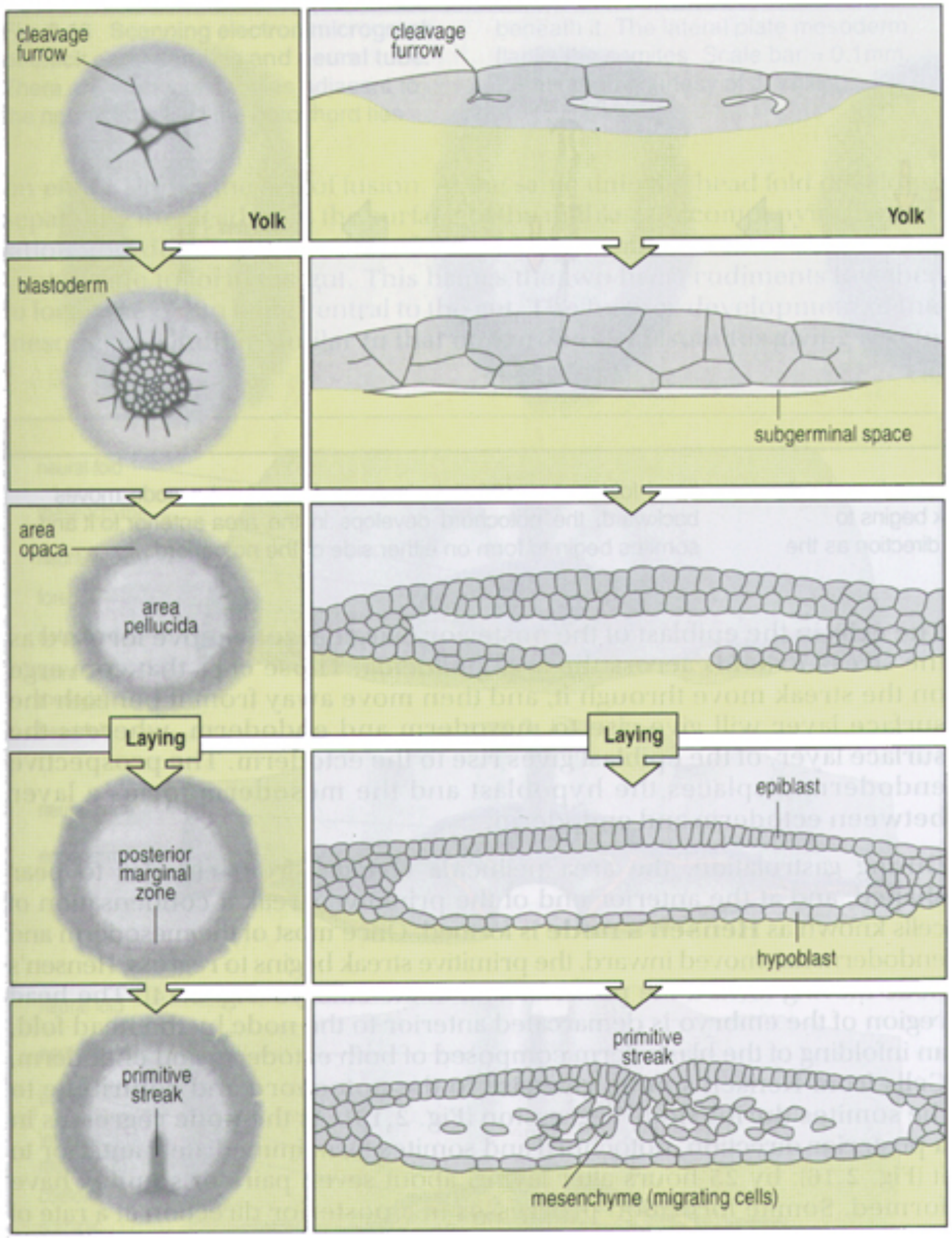
- Amphibians have **holoblastic cleavage**
  - Each early cell division produces daughter cells of roughly equal size
  - Yolk concentration is highest at the bottom and cell division slows there



Amphibians have a ball-like blastula

Reptile Cleavage

- Reptiles have **meroblastic cleavage**
- The cleavage furrow only partially penetrates into the yolk ("incomplete cleavage")



The reptile blastula is a flat disc of cells covering 1/3 of the surface of the original ovum

Review of Development

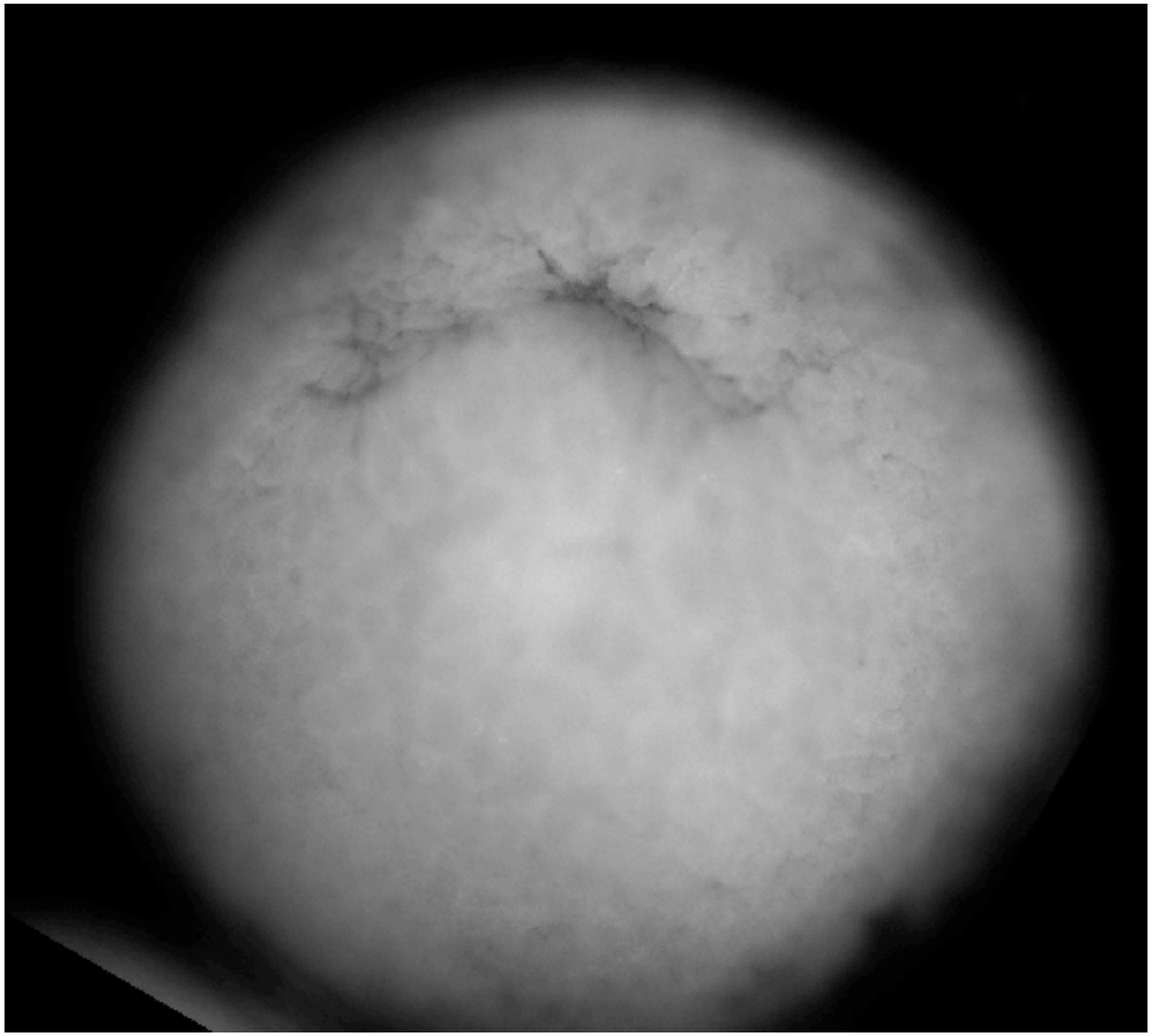
- The next stage of development is **gastrulation**, where the three embryonic tissue layers are formed
- Ectoderm, mesoderm, and endoderm
- This stage results in the formation of the pharyngula stage - all basic organ systems are established

Amphibian Gastrulation

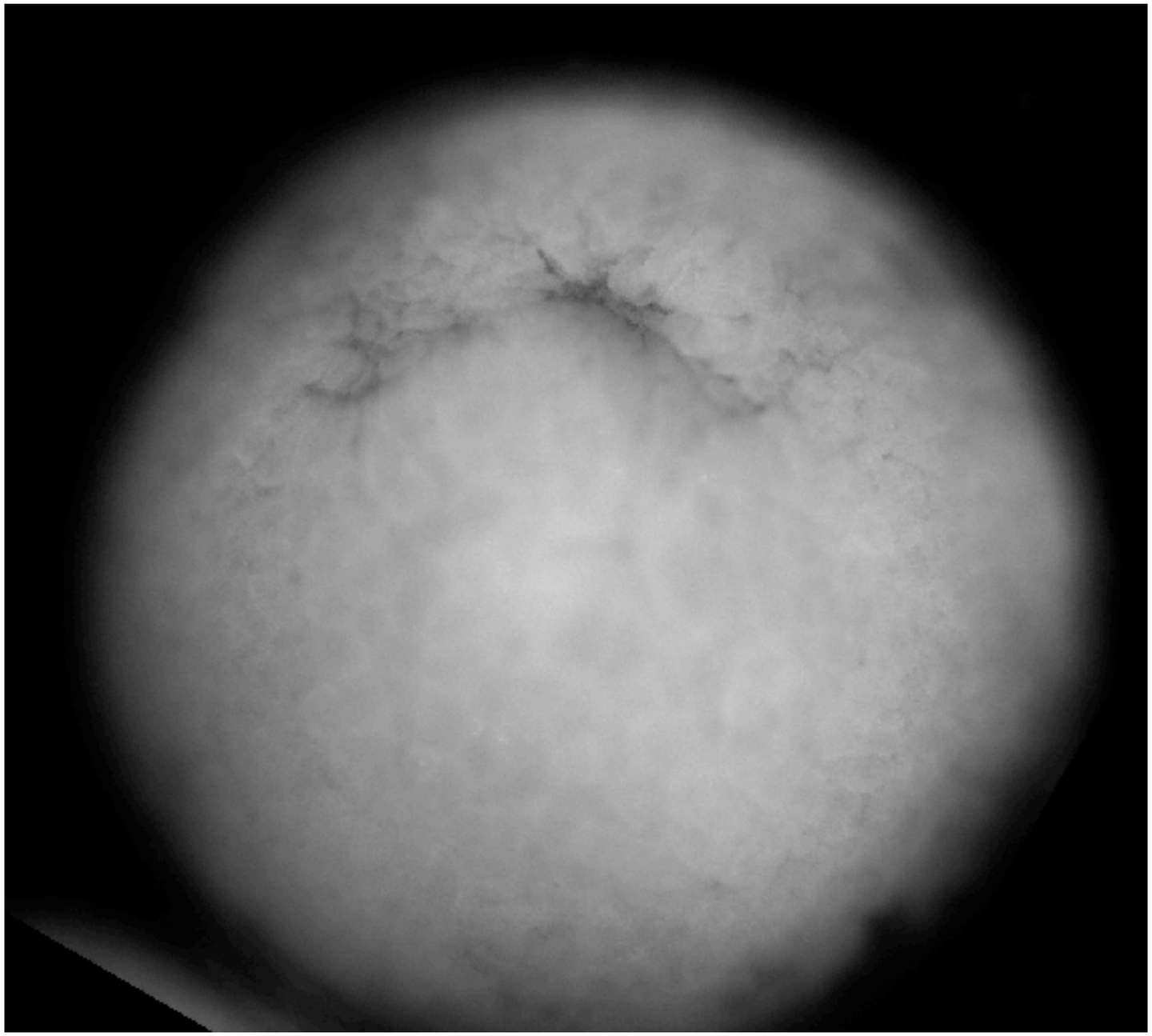
- **Gastrulation** starts with a small indentation on the upper surface of the blastula
- Cells migrate inwardly to form the gut tube

Amphibian Gastrulation

- The embryo elongates during **neurulation**, the formation of the neural tube
- The pharyngula contains all yolk within its body as part of the digestive system



http://www.youtube.com/watch?v=qisrNX3QjUg



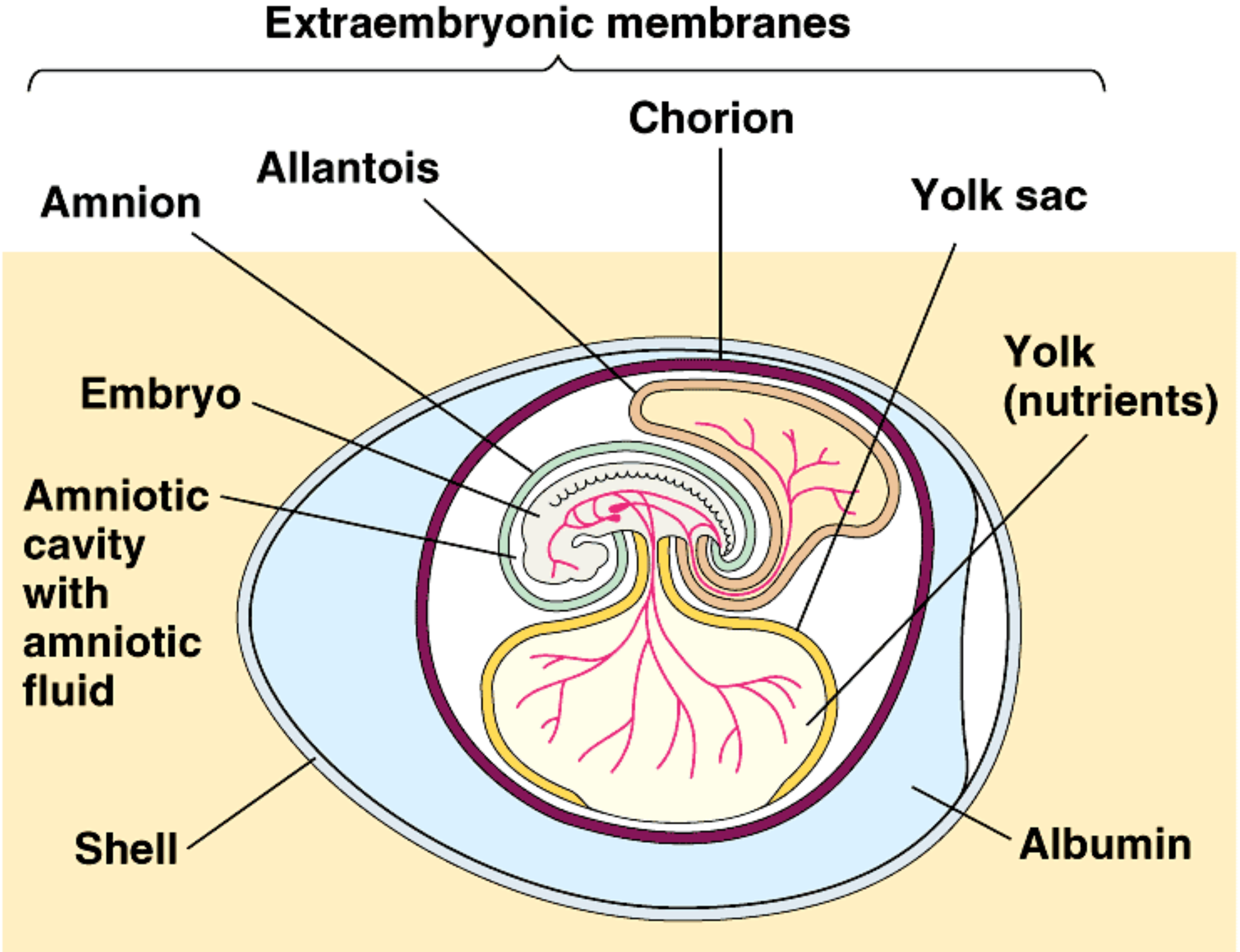
http://www.youtube.com/watch?v=qisrNX3QjUg

Reptile Gastrulation

- During gastrulation, a **yolk sac** is formed
- The endodermal tissue grows outward and eventually encompasses the yolk mass
- Ectoderm and mesoderm grow upward into an amniotic sheath

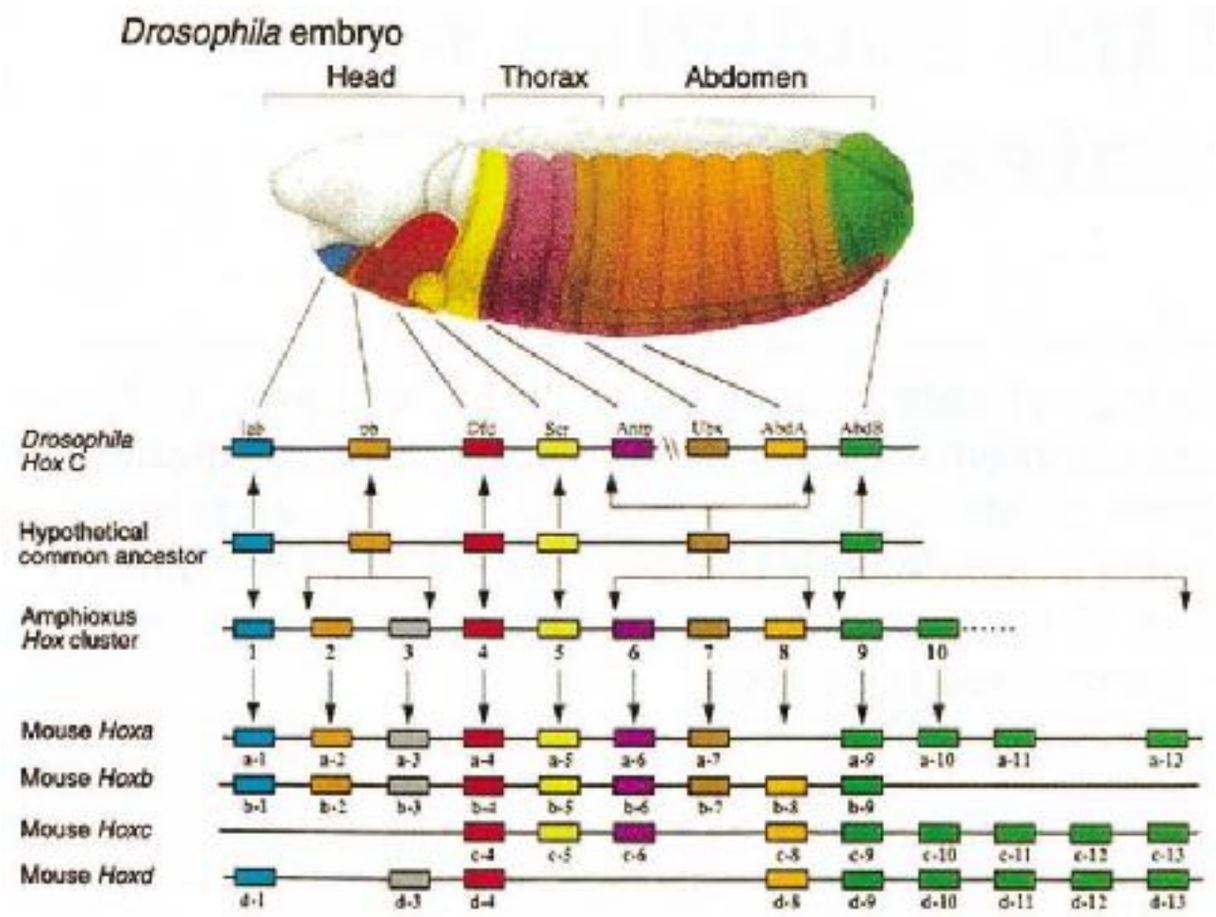
Reptile Gastrulation

- Outer two layers of reptile pharyngula form the chorion, which will encase both yolk and embryo
- Inner two layers form the amnion, which encloses the embryo



Morphogenesis

- **Morphogenesis** is the the biological process that causes an organism to develop its shape
- The final shape of an animal depends on the relative timing of morphogenesis


Drosophila embryo
Head
Thorax
Abdomen
Drosophila *Hox C*
lab
pb
Dfd
Scr
Antp
Ubx
AbdA
AbdB
Hypothetical common ancestor
Amphioxus *Hox* cluster
1
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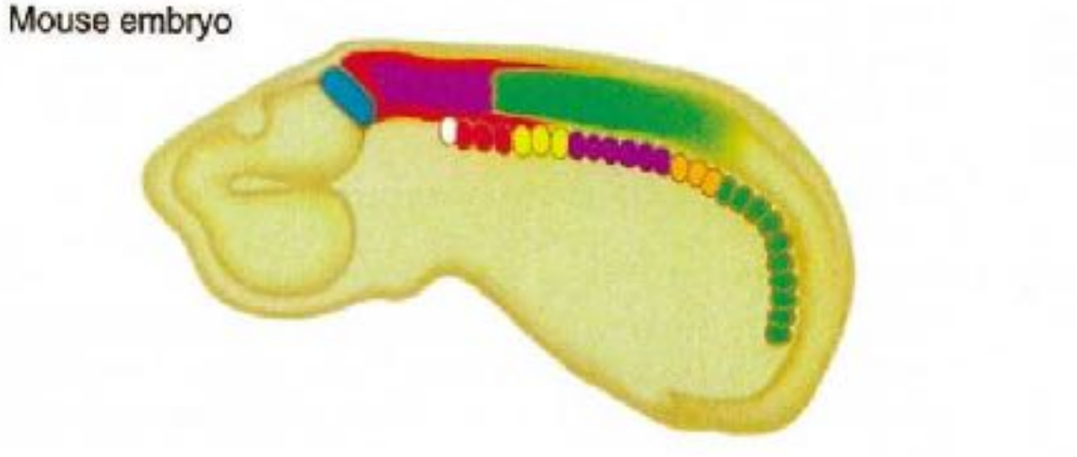
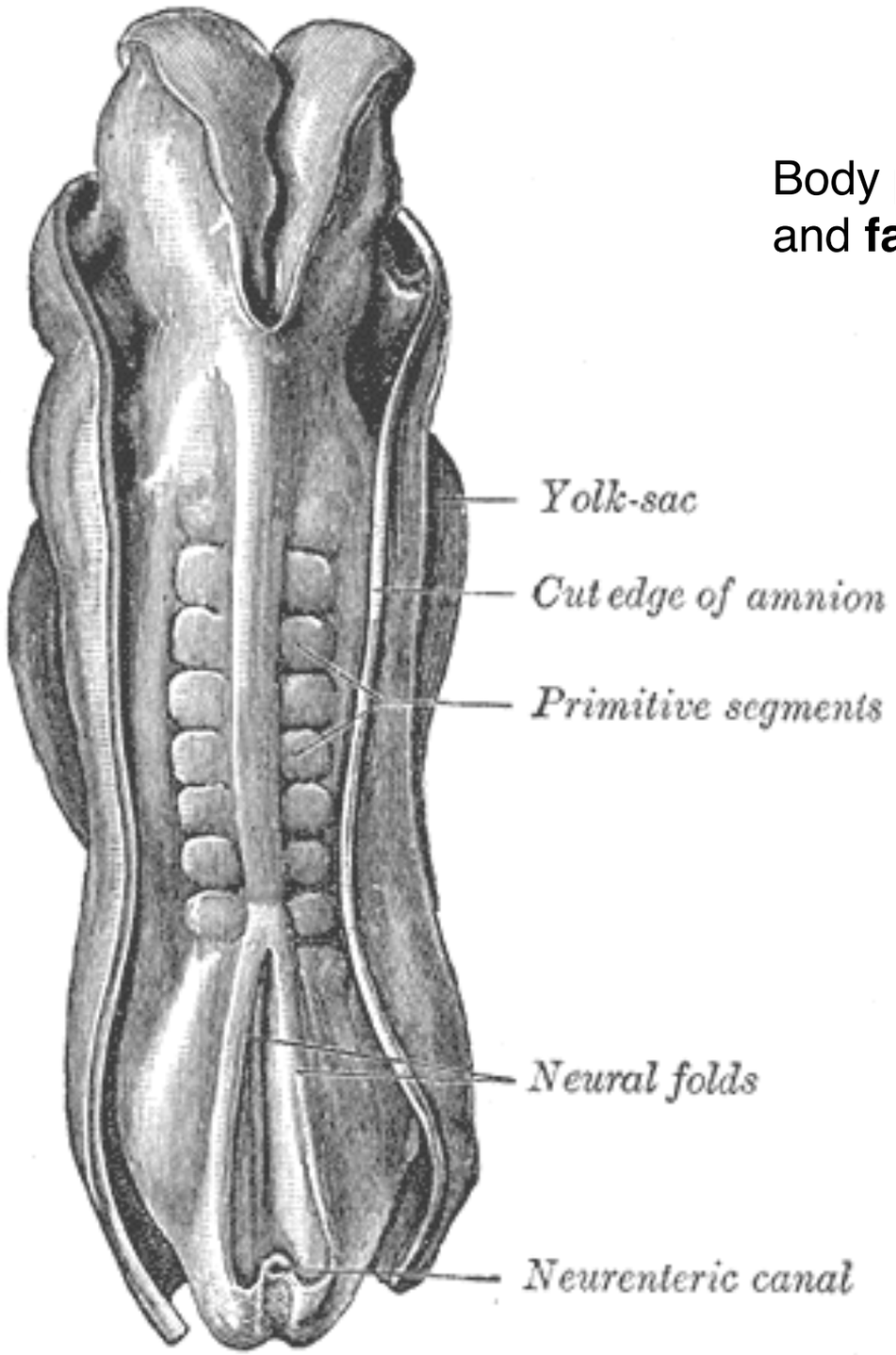
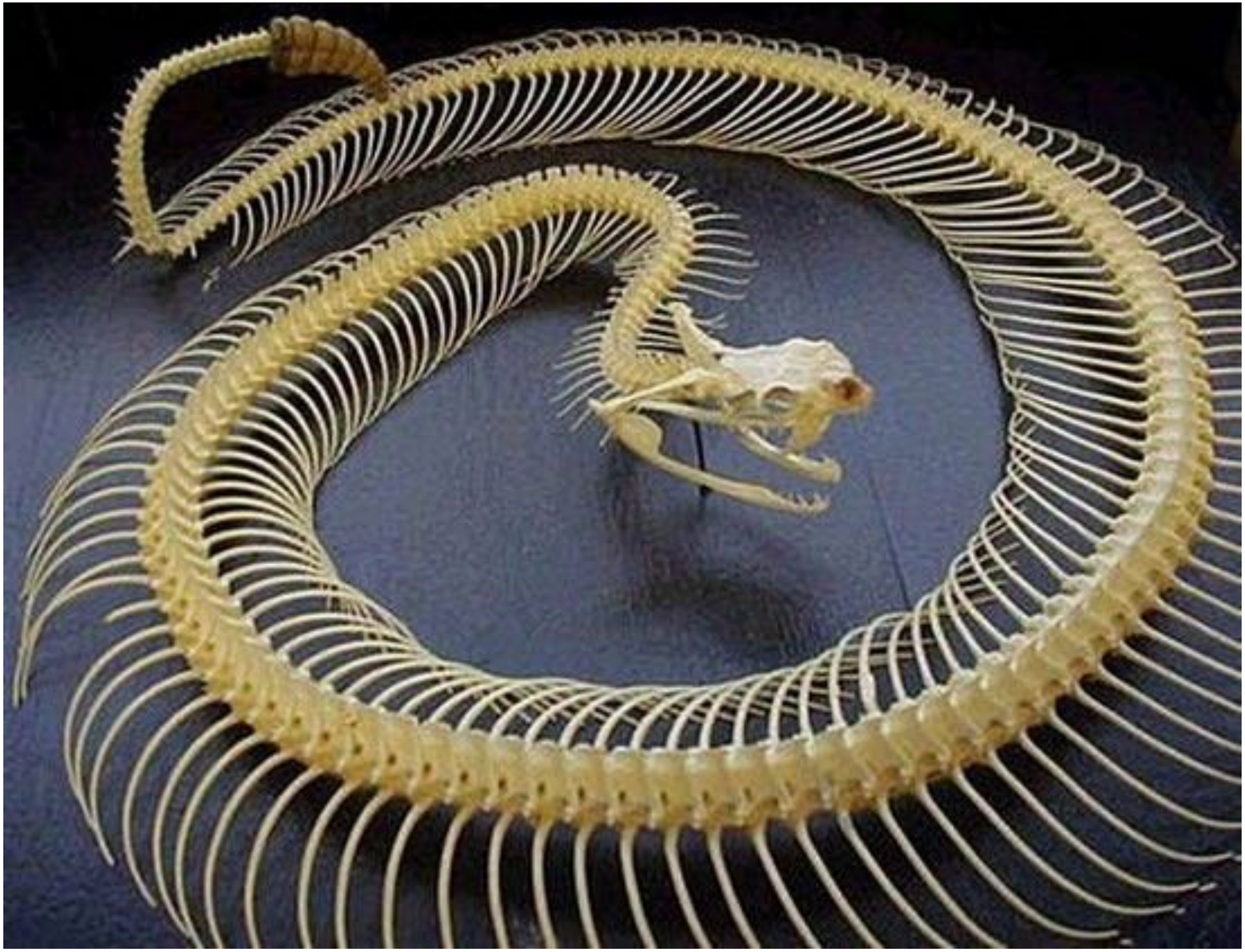
9
10
Mouse *Hoxa*
Mouse *Hoxb*
Mouse *Hoxc*
Mouse *Hoxd*


Mouse embryo

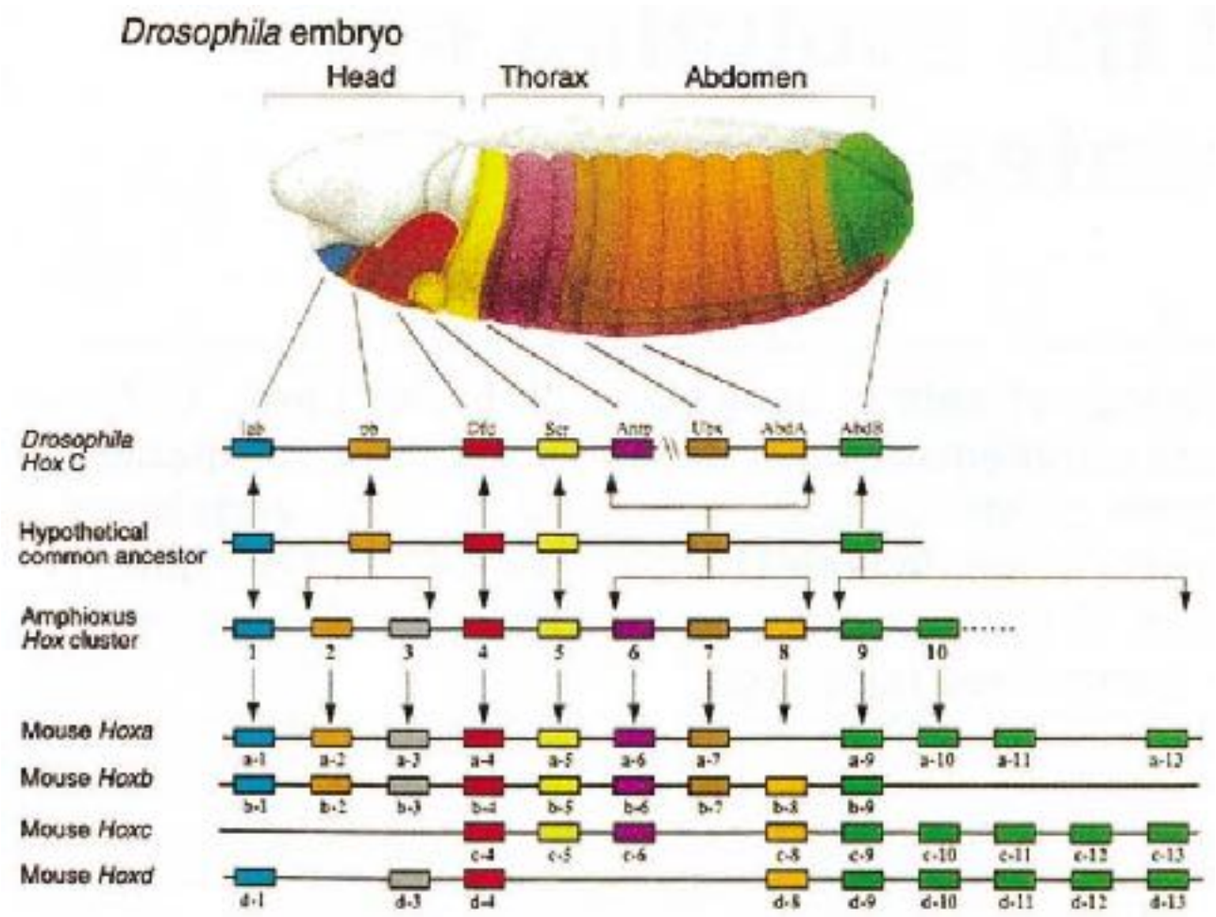


Body plan depends on **position** and **fate** of somites

(Somites = mesodermal segments that give rise to the vertebrae)



Snakes can have **hundreds** of precaudal vertebrae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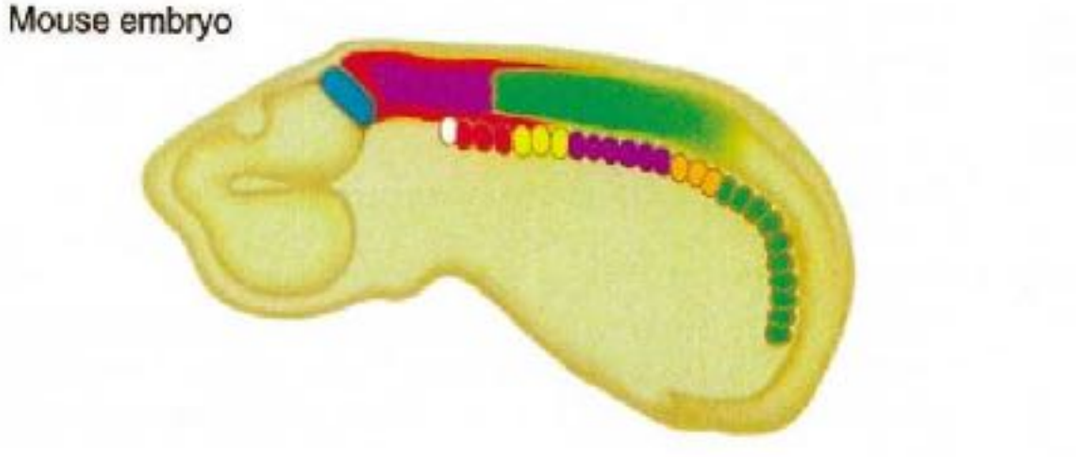
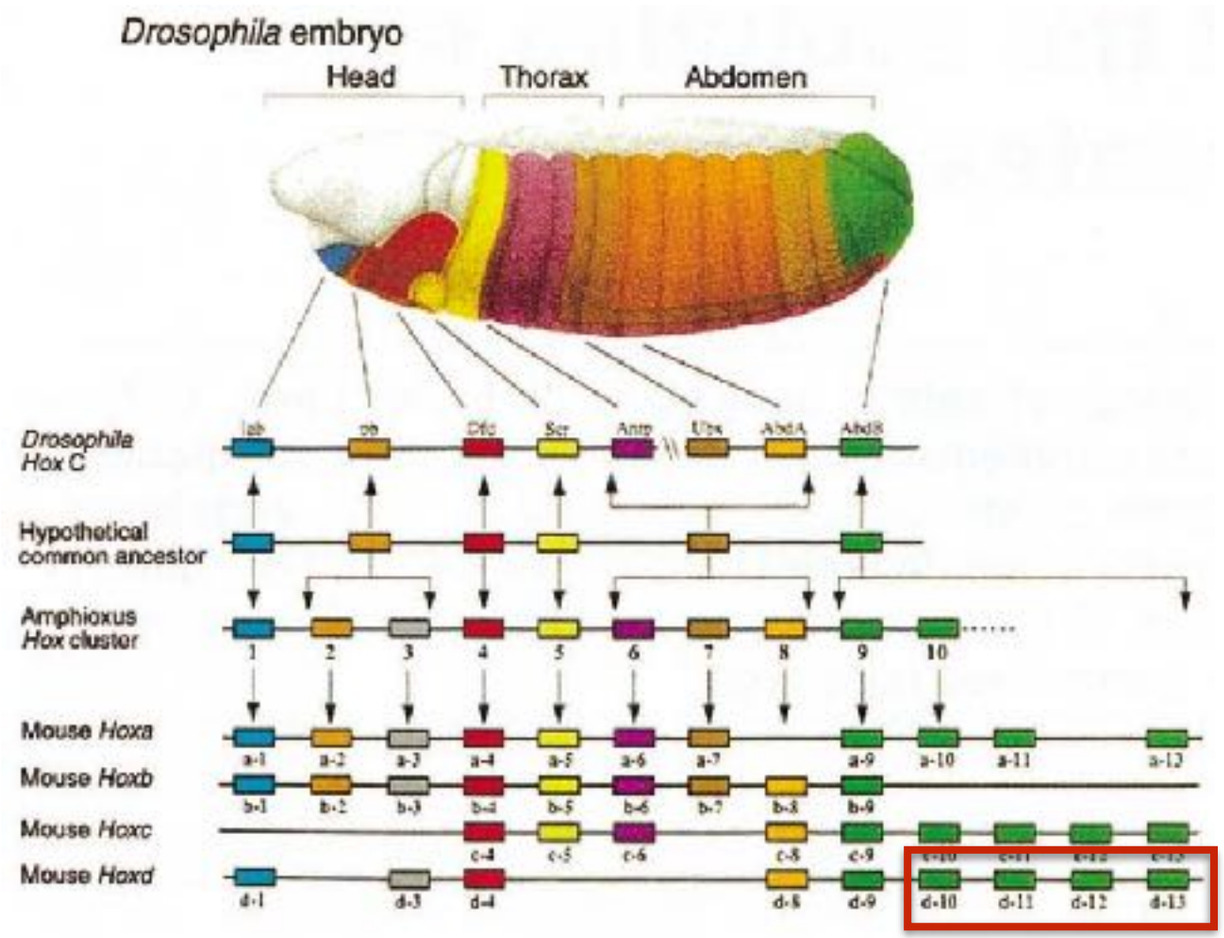
Mouse *Hoxa*
Mouse *Hoxb*
Mouse *Hoxc*
Mouse *Hoxd*


Mouse embryo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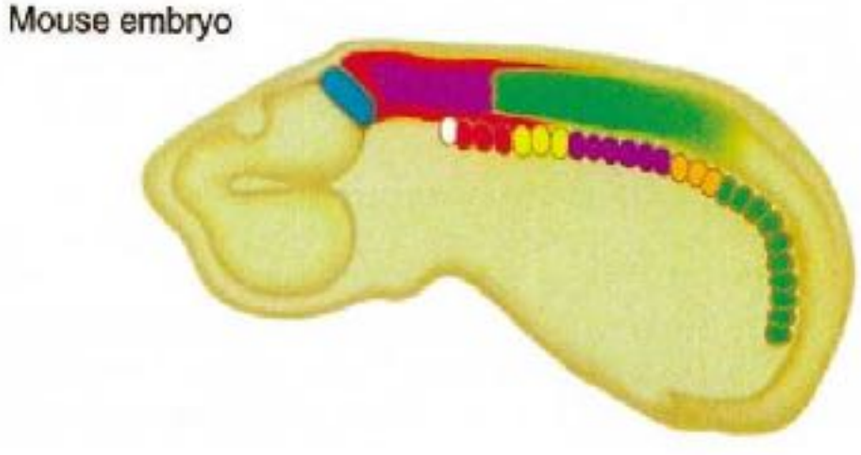
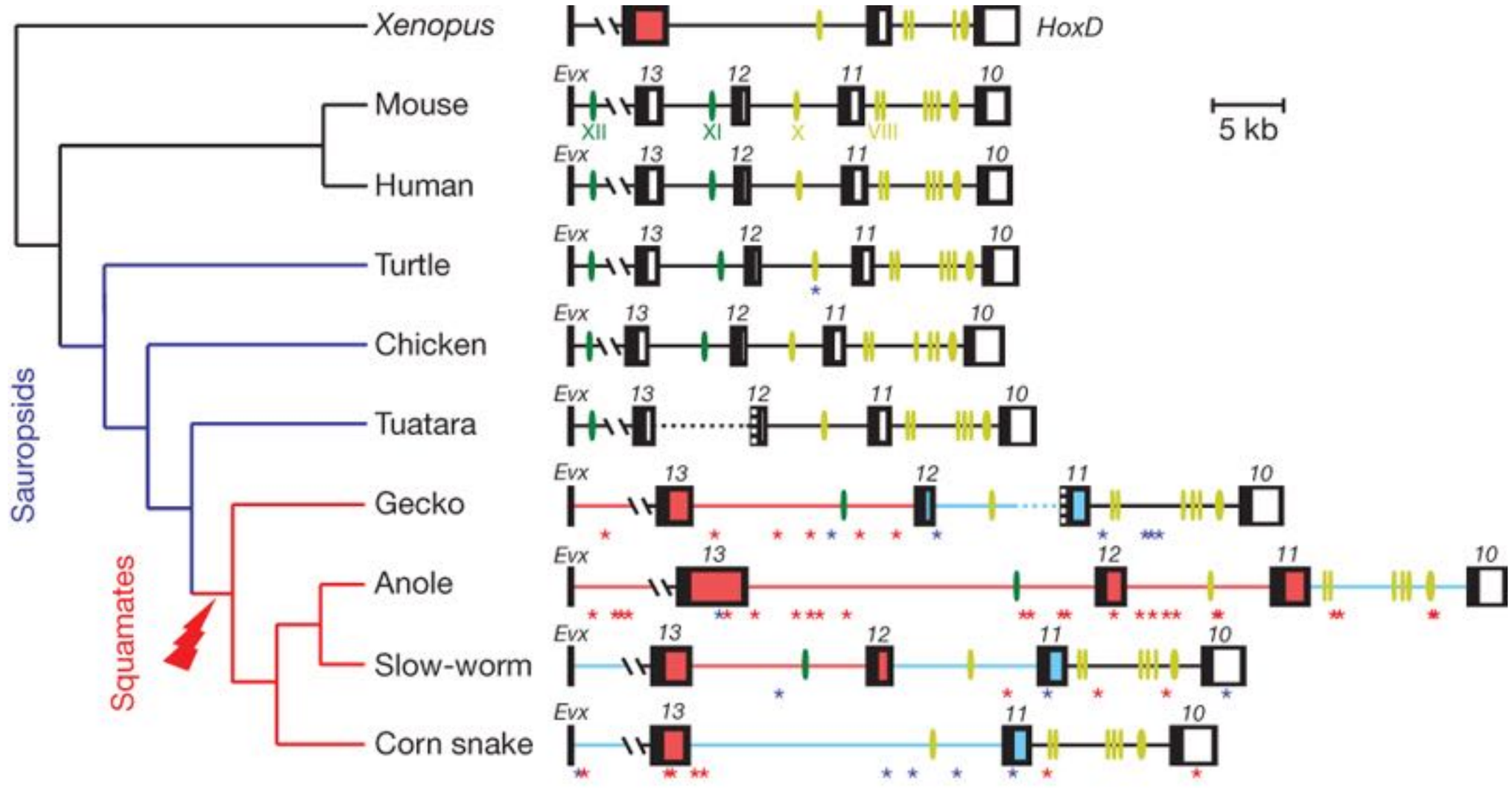
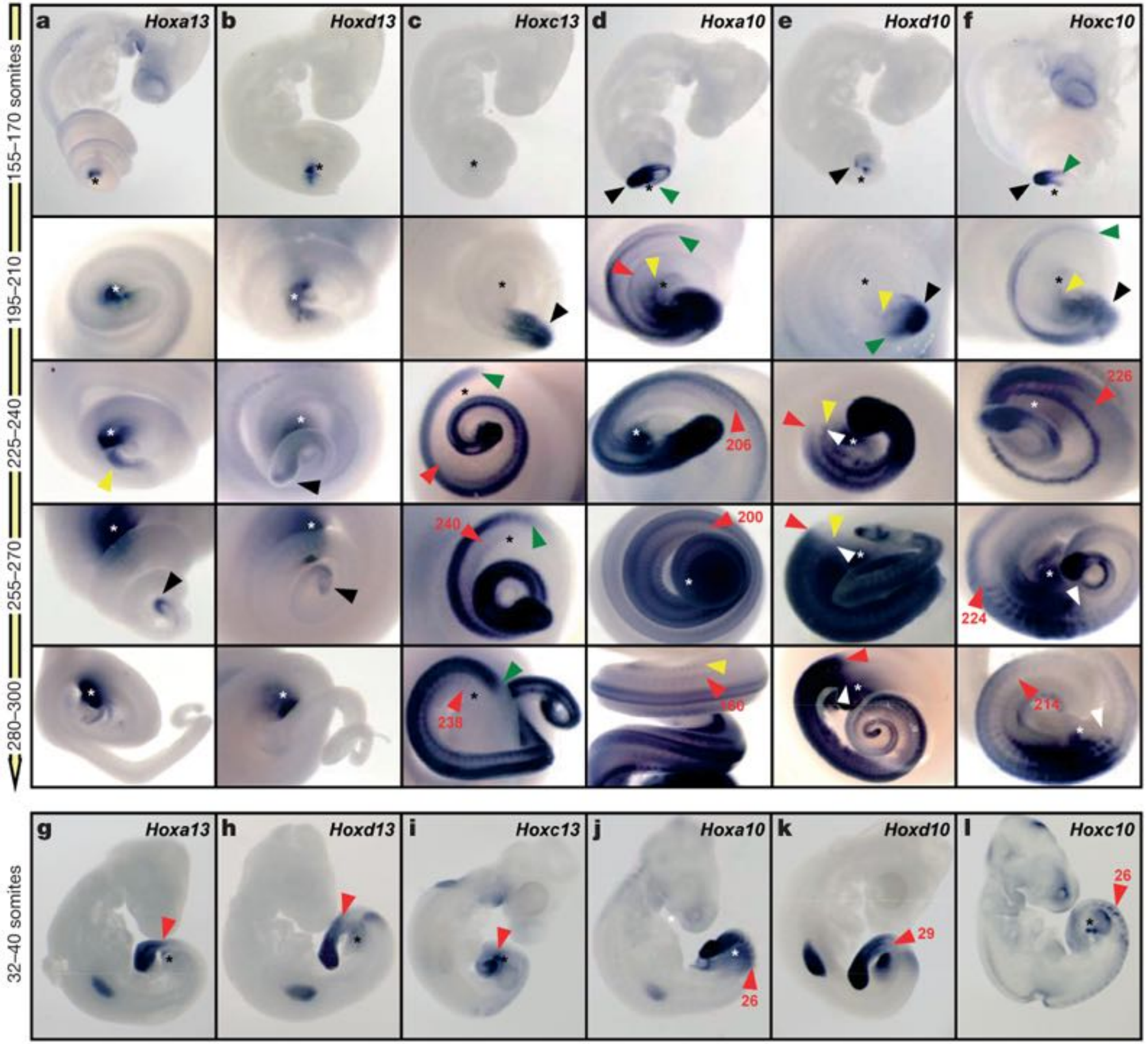
Mouse *Hoxa*
Mouse *Hoxb*
Mouse *Hoxc*
Mouse *Hoxd*


Mouse embryo

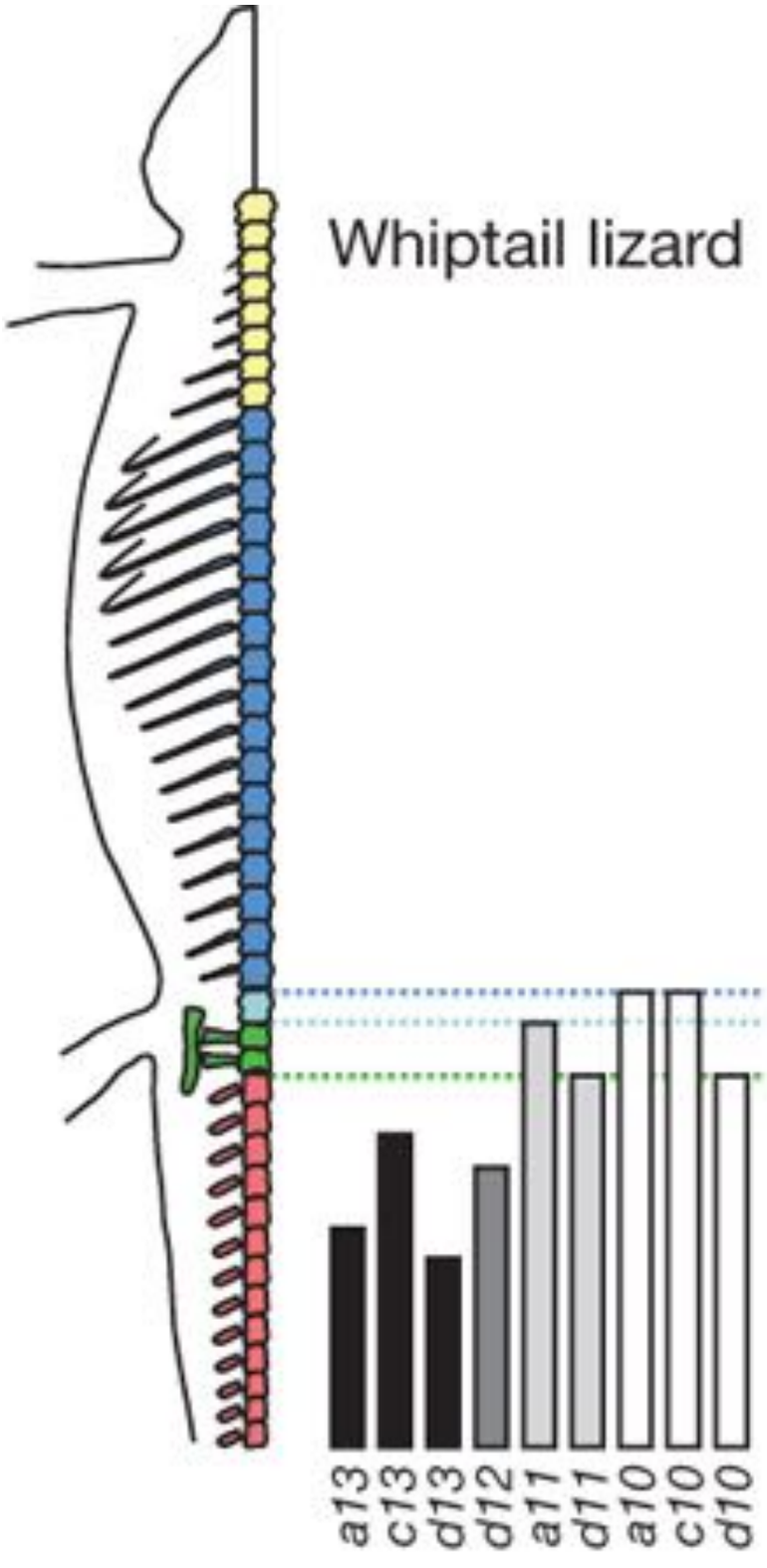
HoxD cluster across tetrapods



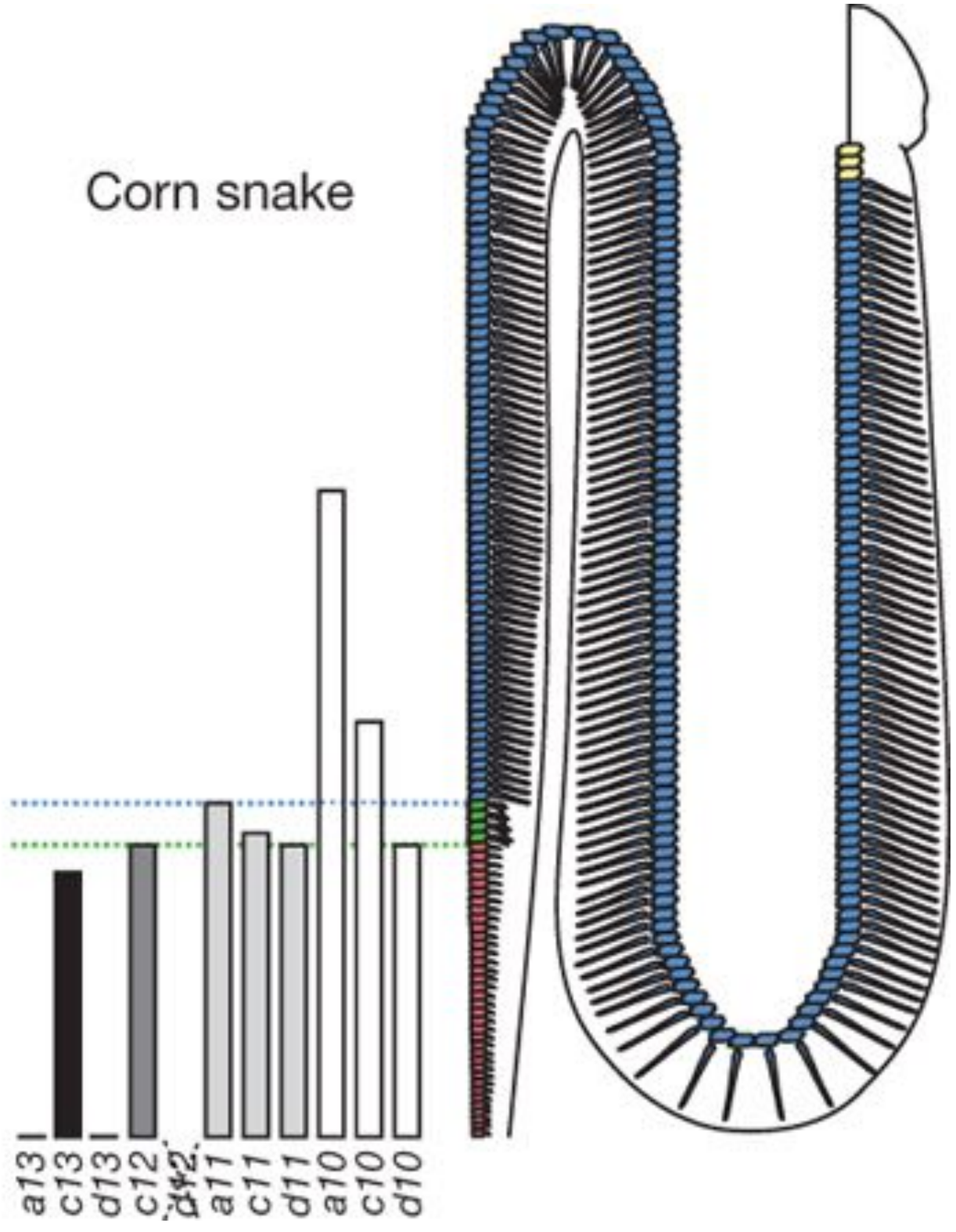
Di-Poi et al. Nature 2010


a Hoxa13
b Hoxd13
c Hoxc13
d Hoxa10
e Hoxd10
f Hoxc10
155–170 somites
195–210
225–240
255–270
280–300
206
226
240
200
224
238
160
214
32–40 somites
g Hoxa13
h Hoxd13
i Hoxc13
j Hoxa10
k Hoxd10
l Hoxc10
26
29
26

Whiptail lizard



Corn snake



Heterochrony

- Heterochrony: changes in the timing and/or rate of growth of certain tissues
- Development can:
  - speed up, start earlier, or end later
  - slow down, start later, or end earlier
  - some combination of these

Patterns of Heterochrony

- **Paedomorphosis** occurs when a trait fails to develop to the extent observed in related species
- In paedomorphic species one can observe larval traits in otherwise "adult" individuals

Patterns of Heterochrony

- **Peramorphosis** occurs when a trait develops further than the extent observed in related species
- Peramorphic traits are less common in reptiles and amphibians

Across species

isomorphic

paedomorphic

peramorphic

Across species	Within species
isomorphic	isotypic
paedomorphic	paedotypic
peramorphic	peratypic

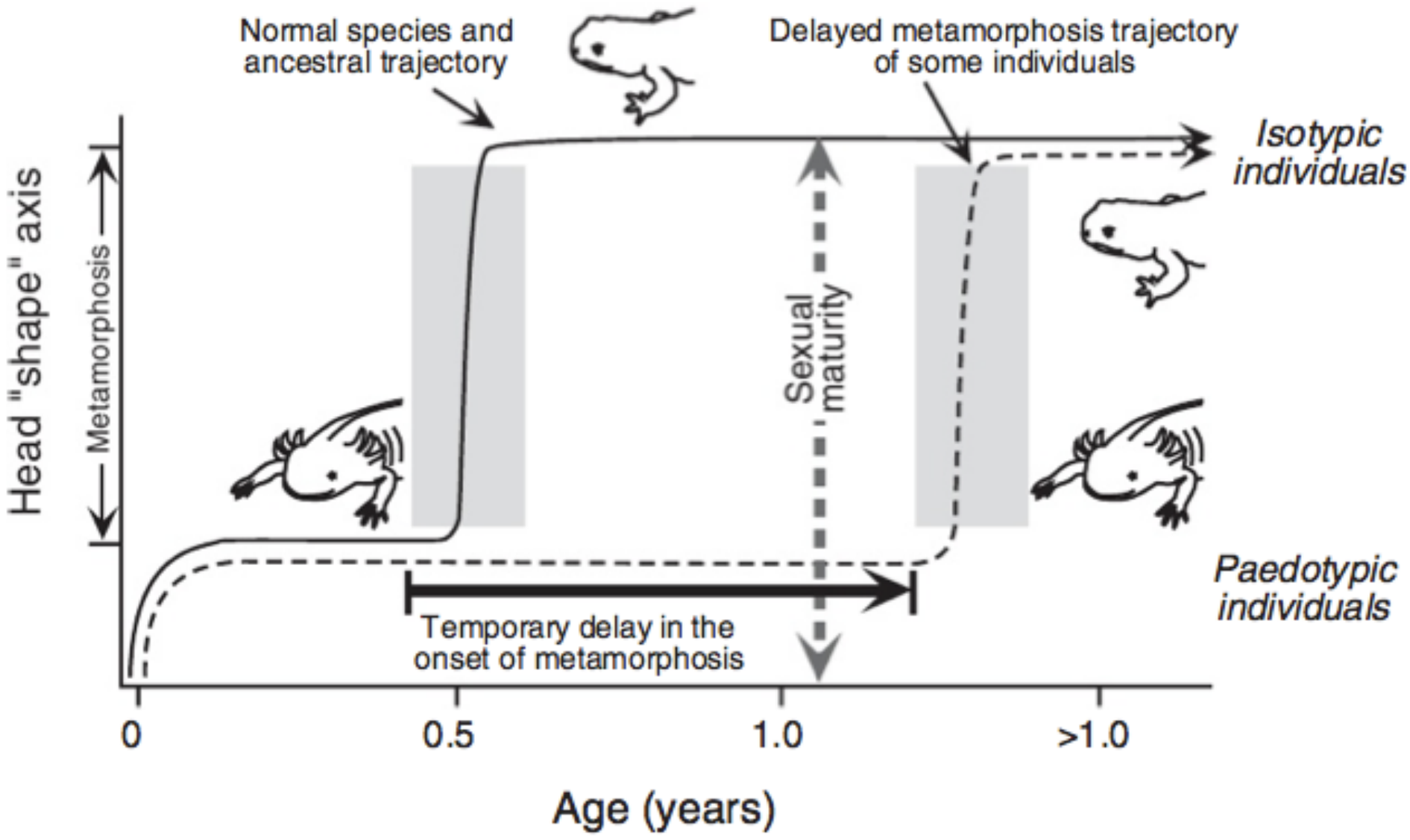

Normal species and
ancestral trajectory
Delayed metamorphosis trajectory
of some individuals
Isotypic
individuals
Head "shape" axis
Metamorphosis
Sexual
maturity
Paedotypic
individuals
Temporary delay in the
onset of metamorphosis
0
0.5
1.0
>1.0
Age (years)

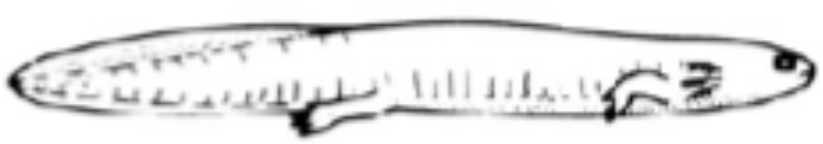
Figure 2.2

Growth and Development

- Sex determination
- Development: embryogenesis and morphogenesis
- Metamorphosis

Amphibian larvae

- Amphibian larvae ("tadpoles") are generally free-living and most feed
- (some depend on yolk stores)
- Caecilian and salamander larvae resemble adults but with pharyngeal slits, gills, tail fins, and specialized larval dentition

Salamanders	Frogs
Aquatic/pond types	
	
Ambystoma tigrinum	*Sphaenorhynchus orophilus*
Aquatic/stream types	
	
Eurycea bislineata	*Rana holsti*

Ambystoma mavortium (pond)

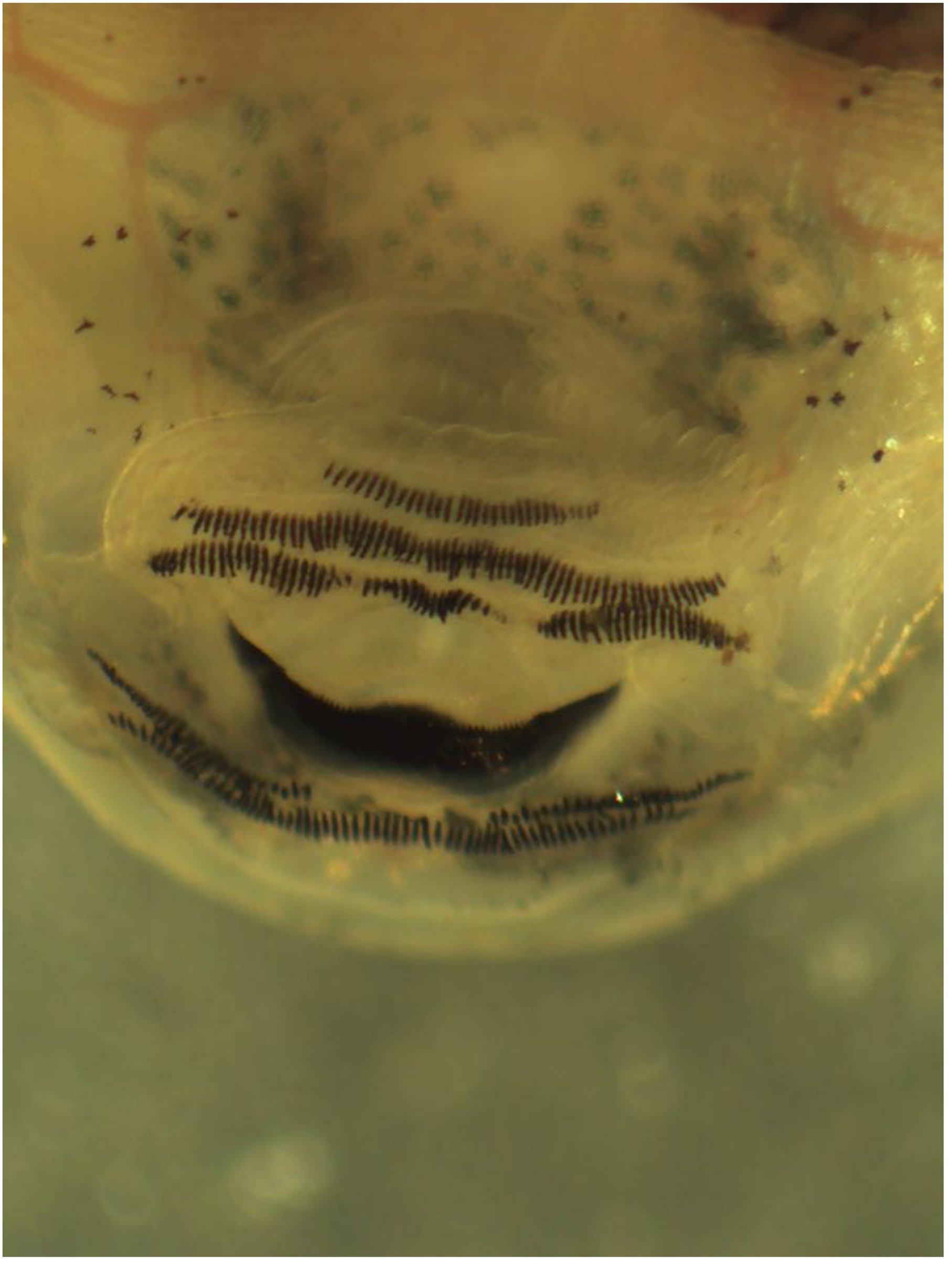
Eurycea bislineata (stream)

Tadpoles

- Frog larvae are highly specialized
- Some have external gills (replaced by internal gills in neobatrachian frogs)
- Spherical body with coiled intestine
- Long muscular tail

Tadpoles

- Oral disc encloses mouth
- Papillae around edge (sensory?)
- Keratinous mouthparts related to diet: jaw sheaths, labial teeth
- Cartilaginous skeleton



Metamorphosis

- Transformation of amphibians from the larva to a miniature adult
- Usually associated with transition from aquatic to terrestrial or semiterrestrial lifestyle
- Changes occur gradually but over a restricted time period

- Tadpole development can be classified into Gossner stages

- Stages go from 1 (embryo) to 46 (metamorphosis)

- Hatching usually occurs at stage 17

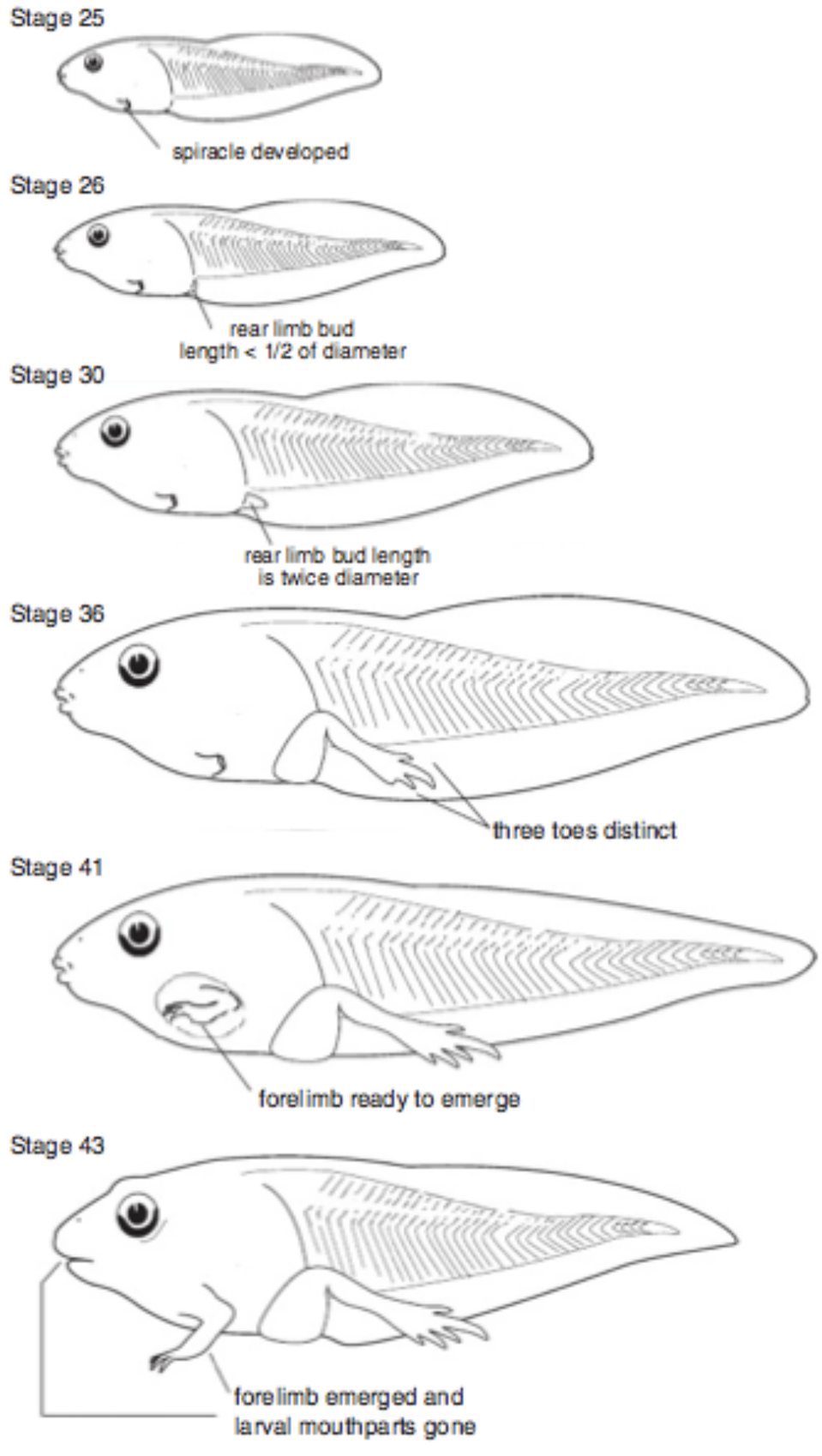


FIGURE 2.5 Selected larval stages of a typical anuran. Stage terminology from Gosner (1960).

Metamorphosis

- Larval life span differs between and within species, from <20 days (Scaphiopodidae) to multiple years
- Initiated by the hormone thyroxine
- Part of a complex interplay of hormones and receptors controlling onset of metamorphosis

Growth and Development

- Sex determination
- Development: embryogenesis and morphogenesis
- Metamorphosis